Notice of Allowability	Application No.	Applicant(s)	
	10/634,168	CHUNG ET AL.	
	Examiner	Art Unit	
	Michael K. Luhrs	2824	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *07 March 2005*.

2. ☒ The allowed claim(s) is/are *1-15*.

3. ☒ The drawings filed on *05 August 2003* are accepted by the Examiner.

4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☒ All b) ☐ Some* c) ☐ None of the:
      1. ☒ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date 3/7/05 & 11/26/04
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____.
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☒ Other *search updated*.

DETAILED ACTION

Information Disclosure Statement

1. Examiner carefully considered on applicant's I.D.S. dated 07 March 2005 and 26 November 2004; drawn to Sharan et. al. and Liaw et. al., respectively, and have been discussed them in the pertinent art below.

2. Examiner carefully considered on applicant's I.D.S. dated 01 July 2004 in previous action. Again, Tseng et. al. teaches in-situ doped polysilicon in the contact hole, yet lacks the chamber pressure of actually doping the contact hole with the first impurity into the exposed silicon [already] having the first impurity.

Priority

3. Priority to Korean application KR 10-2002-0081741 is acknowledged.

EXAMINER'S AMENDMENT

4. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

5. Authorization for this examiner's amendment was given in a telephone interview with Attorney O'Sullivan on 04/22/05 and 5/6/06.

In the Specification p. 4, line 30 change "second" to read --first--.

In Claim 1, line 5, insert the word –pre-flow-- prior to "gas".

In Claim 1, line 7, insert the words --prior to-- after "and".

In Claim 1, line 7, remove semicolon after "Torr", and remove "and" after "Torr"

In Claim 3, line 1, insert the word –pre-flow-- prior to "gas" and replace "the" with –said--.

In Claim 7, line 2, insert the word –pre-flow-- prior to "gas".

In Claim 8, line 2, insert the word –pre-flow-- prior to "gas".

In Claim 10, line 2, insert the word –pre-flow-- prior to "gas".

In Claim 12, line 6, insert the word –pre-flow-- prior to "gas".

6. The application has been amended as follows: Claims 1, 3, 7, 8, 10 and 12 now read:

1. A method of fabricating a contact of a

semiconductor device, comprising:

patterning an interlayer dielectric of the semiconductor device to form a contact hole that exposes a silicon-based region of a first impurity type;

doping the exposed silicon-based region with a pre-flow gas containing an element of the first impurity type under a chamber pressure of from about $6x10^{-2}$ to about $6x10^{-4}$ Torr~~, and~~ prior to

forming a contact plug in the contact hole.

3. The method of Claim 1, wherein ~~the~~ said pre-flow gas containing an element of the first impurity type comprises AsH_3 and/or PH_3.

7. The method of Claim 1, wherein doping the exposed silicon-based region with a pre-flow gas containing an element of the first impurity type and forming a contact plug in the contact hole are performed in a chamber of the same manufacturing apparatus in-situ.

8. The method of Claim 3, wherein the doping the exposed silicon-based region with a pre-flow gas containing an element of the first impurity type is performed at a temperature of from about 400 to about 800 °C.

10. The method of Claim 3, wherein the doping the exposed silicon-based region with a pre-flow gas containing an element of the first impurity type is performed for from about 30 to about 180 seconds.

12. The method of Claim 1, wherein patterning an interlayer dielectric of the semiconductor device to form a contact hole comprises patterning an interlayer dielectric of the

semiconductor device to form a contact hole that exposes a first silicon-based contact plug of a first impurity type and wherein doping the exposed silicon-based region comprises doping the exposed silicon-based contact plug with a pre-flow gas containing an element of the first impurity type under a chamber pressure of from about $6x10^{-2}$ to about $6x10^{-4}$ Torr.

Allowable Subject Matter

7. Claims 1-8 and 10-15 are allowed.

8. The following is an examiner's statement of reasons for allowance: There was no suggestion or teaching in the prior art of doping the exposed silicon based region (having already, the first impurity) with a preflow gas containing an element of the first impurity type under a chamber pressure from about $6x10^{-2}$ Torr to about $6x10^{-4}$ Torr, prior to, forming the contact plug.

9. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Response to Amendment

10. Examiner considered argument by applicant, agrees that the pressure is of different range in Sharan and also agrees the optimization is not necessarily tenable, yet the applicant's *suggestion* to a **plasma** is misdirected, as there is no mention of a plasma in applicant's application.

Conclusion

11. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure: Jeon et. al. USPN 6,667,220, teaches the patterned ILD layer 25 (line 63, col. 2), in Fig. 3a, to expose silicon substrate 20, having predetermined device structure, i.e. active regions (line 26, col. 1) are inherent therein (albeit are not illustrated), prior to the junction electrode), then the exposed silicon region is doped with a gas containing an element of the first impurity (i.e. PH3, B2H4, or AsH3 (as in line 22 of col. 3 and line 53, of col. 3) at a chamber pressure of either low or high CVD (lines 6-9, col. 3) which is inherently inclusive to the chamber pressure indicated by applicant) thereby the doping and the contact plug are formed in the contact hole as '40' in Fig. 3B and '65' in

Fig. 3f respectively for n and p type plug electrodes. Jeon teaches a pressure pre-treatment of the contact hole at 1 to a few hundreds Torr, albeit lacks a preflow of the impurity gas, (Jeon's pressure is also not as much of a vacuum as indicated by applicant). Hence Jeon lacks the preflow of the impurity gas prior to forming the contact. Jeon, however notably, does provide a selective epitaxy growth into the contact hole.

Liaw et. al. USPN 5,554,565 found on applicant's IDS is pertinent for discussion: Liaw et. al. teach the first impurity doping of the exposed substrate having the first impurity in lines 36-39, column 4, see Fig. 2D, of a patterned (line 27, column 4) IDL as SiO_2-BPSG-SiO_2 (line 24, column 4), and forms contact plug: tungsten plug 30 (line 64, column 4). Laiw et. al. are explicit in the method, i.e. Liaw et. al. are implanting these *ions* (in lines 36-37, column 4). Laiw et. al. teach the first impurity type is an n-type as n-type impurity, phosphorus (line 40, column 4), into already doped n-type silicon, see, that it is a 'corresponding impurity' that that of the exposed silicon (in lines 36-37, column 4). Laiw et. al. are apparently absent of applicant's amended claim language drawn to the chamber pressure.

Van Zant, Peter, Microchip Fabrication, 4th ed. McGraw-Hill, pp. 340-1, Van Zant teach the well known chamber pressure for *ion implant* is at about 10^{-3} torr, (which is a pressure that falls directly inside the applicant's range of $6x10^{-2}$ Torr to about $6x10^{-4}$ Torr chamber pressure for the pre-flow gas). Van Zant teaches this pressure for ion implanting. Dopant sources AsH_3 and/or PH_3 are well known, for example Van Zant, chart, p. 331 shows that PH_3 is a source gas to dope phosphorus, and such sources are typically hydrated forms of the dopant atom as stated on p. 333, line 4.

Sharan et. al. on applicant's I.D.S., teach the contact hole yet fails to teach the silicon doped with the first impurity and then the doping with the gas of the first impurity at $6x10^{-2}$ torr to about $6x\ 10^{-4}$ Torr, (i.e. applicant's chamber pressure).

Ogino teaches patterned ILD for a contact hole as opening 45 in insulating film 43 (lines 44-46, column 1), exposing drain region 42, which is an n-type diffused region (line 46-7, col. 1 and line 41-42, col. 1), subsequently a SEG (selective epitaxy growth) of silicon as layer 46 containing N-type impurity (line 49, col. 1) causes a doping of the exposed region 'to reduce electrical resistance' line 54, col. 1) as in prior art discussed whereas, the specific chamber pressure of the SEG is 100 Torr (line 36-7, col. 4), whereas the present application clearly has a lower pressure than as compared to Ogino's SEG pressure which is responsible for the doping. Hence it would not be

obvious to resort to such a low pressure when SEG is used to form the contact plug, since SEG can be generally performed at merely 100 Torr.

Other relevant art : Benyon, Jr. et. al. USPN 4,313,809 teach an inert gas flow after making the contact opening. Yang et. al. USPN 5,880,013 purges with nitrogen or argon before ion implantation. KR1-202817 teach pressure of **2 Torr** for the second doping of the same impurity ('2' and '21' in Fig. 1(a)). 2004057600 A (Pub. date July 2, 2004) teach improved contact resistance to landing plug by using plasma doping (of hole 49a having doped area 43 and the added doped area 51, see the Figure.) Mizuno et. al. USPN 4,912,065, teach **plasma** doping of source/drain in vacuum of $5x10^{313}$ Torr [sic] (probably 10^{-3}) or more (lines 36-7, column 3). Walthar USPN 6,716,727, teaches chamber pressure of 1 millitor to about 500 millitorr for **plasma** doping, (col. 7, lines 59-60). Fiordalic et. al. USPN 5,429,989, teach doping region typical in column 4: that "a doped region is usually formed in a silicon substrate at a location where an electrical contact is to be made to the substrate.", (lines 32-5, col. 4). Hada USPN 5,753,555, teach that for selective epitaxial growth a pressure of $10^{-4} - 10^{-5}$ Torr is used, (line 17, col. 4). Wagner et. al. USPN 6,093,625, teach an apparatus for implanting where the chamber pressure can be 10^{-4} to 10^{-5} torr (line 39, col. 5). By the assignee: Lee et. al. USPN 6,797,559 teach a preflow of silane, and USPN 6,849,559 teach in-situ cluster apparatus. Chung et. al. USPN 6,767,834 teach a pretreatment module. Park et. al. USPN 6,509,263 teach injecting PH_3 into the contact holes to reduce contact resistance, with heat treatment, (no mention of chamber pressure).

See that, Cheong USPN 6,844,259 teaches the flushing gas flow prior to the contact fill, yet fails to suggest the applicant's chamber pressure of from about $6x10^{-2}$ Torr to about $6x10^{-4}$ Torr, prior to, forming the contact plug. Hada et. al. USPN 6,030,894 teach using opposite impurity type to that of the diffused impurity type, for the silicon contact plug.

12. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Michael K. Luhrs whose telephone number is 571-272-1874. The examiner can normally be reached on M-F, 8-5.

13. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Richard T. Elms can be reached on 571-272-1869. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

14. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

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5/6/05

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